Armored aquatic vegetation: Nostoc and Amblystegium calcification in limestone-rich reaches of the Green River

by Val Brenneis

Below Flaming Gorge Dam (FGD) the Green River runs cold and clear. In mid-June, the boulders and cobbles that line the streambed are covered with lush aquatic vegetation. The fine sediments that once made the water run turbid are now stored behind the dam. Fine sediments are scoured away, leaving only the larger rocks that offer more resistance to the downstream pull of the water. The combination of more stable rock substrate and clearer water that allows light to penetrate has resulted in a dramatic increase in aquatic vegetation in this section of the Green River below the dam. Where thin films of algae (known as periphyton) once provided the main source of food for small herbivores, a variety of lush submerged vegetation now grows.

Figure 1. Large rock substrate below FGD

Our group stops to fish a few miles below the dam, at river mile 286. I sit in the slow, shallow water turning over rocks to look for the small insects, crustaceans, and snails that make their home here. In this section of the river, amphipods, or scuds, are the most common invertebrates. There are thousands of them, finding food and refuge from trout in the thick vegetation. The rocks are covered with a dark olive green moss (the bryophyte *Amblystegium*), the vibrant green filamentous algae *Cladophora*, nodules of the blue-green algae, *Nostoc*, and a tough, stringy aquatic macrophyte, *Chara* (Vinson et al. 2006).

Figure 2. *Amblystegium* and *Cladophora* growing in clear water

As I hold the rock in my hand I notice that instead of feeling soft, the *Nostoc* and the bryophyte growing on the rocks feel hard and gritty. Using my fingernails I can crumble apart these hard outer casings. It appears that these primary producers are encased in a layer of calcium carbonate. Although commonly reported in lakes and shallow marine waters, I've never seen this type of calcification in a river.

Figure 3. Calcified *Nostoc* nodules and *Amblystegium*

Dams often expose calcium carbonate rich limestone rock. This limestone dissolves and forms bicarbonate (HCO_3^-) as well as calcium (Ca^{2+}) ions. This results in a well-buffered system where acidification of the water does not occur because the hydrogen ion (H^+) is taken up by carbon-oxygen compounds. These reversible reactions can be shifted in one direction or another by availability of substrates (carbonate or carbon dioxide) and the pH (availability of H^+).

$$\mathbf{CaCO_3\ (limestone)\ +\ H^+ \rightarrow Ca^{2+}(aq)\ +\ HCO_3^-\ (bicarbonate)}$$

$$\mathbf{CO_3^{2-}\ (carbonate) + H^+ \leftrightarrow HCO_3^-\ (bicarbonate) + H^+ \leftrightarrow H_2CO_3\ (carbonic\ acid)}$$

Here below the dam, where carbon dioxide levels are low (due to high productivity) and calcium availability is high (due to presence of limestone rocks) you can find calcification around aquatic vegetation (Arp et al. 2001). As we move downstream, the clarity of the water decreases, along with the amount of aquatic vegetation growing on the rocks. I look for the calcium carbonate precipitate but don't find it as we move through the canyons and Browns Park. At river mile 225.8, just upstream of the confluence of the Yampa and just below the Mitten Park fault, we find more evidence for calcification. While the *Nostoc* grows on sandstone, the Madison limestone formation is a major component of the geology here, once again providing a rich source of calcium carbonate. We use a vial of hydrochloric acid to verify that this hard substance is carbonate. To me, this demonstrates the over-arching connection between the geology, water quality, and the biology of river systems, and serves as a reminder to think broadly and work inter-disciplinarily.

References:

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